



National Aeronautics and
Space Administration

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SAFETY AND MISSION ASSURANCE Metrology and Calibration (323-27) Technical Program Plan (Level 2) FY 2004

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SAFETY AND MISSION ASSURANCE METROLOGY AND CALIBRATION TECHNICAL PROGRAM PLAN

In it's simplest form, when you set your watch, you are performing a calibration. However, the significance of calibration cannot be understated. Every element of numerical data displayed on a Launch Processing System console, every value measured and checked automatically in the seconds before a Shuttle launch, is meaningful because of the accuracy assured by the NASA Metrology and Calibration Program. Although the importance of calibration is most visible during Shuttle launches, it is no less critical to the success of all the various operations of the Agency. Ensuring the soundness of products and services justifies the program as a cost benefit; providing the assurance of safety through measurement quality makes it imperative. NASA has a well defined and mature calibration program, with a focus on the future and a basis rooted in the disciplined past. Accurate measurements will always be important.

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SAFETY AND MISSION ASSURANCE METROLOGY AND CALIBRATION TECHNICAL PROGRAM PLAN

1.0 INTRODUCTION

This plan is prepared by the Functional Principal Center for the Metrology and Calibration Program in response to the Safety and Mission Assurance (S&MA) Technical Program Plan (Level 1). The plan provides a basis for the long range formulation of projects intended to strengthen appropriate areas and meet strategic goals. The scope of this technical program plan is inclusive of all NASA Centers and Field Installations. Participation by the metrology and calibration community is accomplished through a technical working group sponsored by the Office of Safety and Mission Assurance (OSMA).

2.0 OBJECTIVE

The objective of this plan is to identify projects that provide for an innovative and rapid transfer of metrology and calibration technologies, processes, and techniques to provide for safety, reliability, maintainability, and quality assurance enhancements. This will be accomplished through the involvement of a NASA metrology and calibration community that is highly motivated, trained, and properly equipped to provide necessary services and meet the requirements of the Safety and Mission Assurance Program.

2.1 Purpose

This plan is published annually in order to provide the Office of Safety and Mission Assurance (OSMA) with a comprehensive Metrology and Calibration Program status of projects that is inclusive of all NASA Centers and Field Installations. The plan provides for the identification of program level opportunities, and recommends projects to strengthen appropriate areas and meet strategic goals. Project proposals are developed using an established funding rationale to ensure that they enhance safety and provide improved mission assurance. Recommendations for funding in accordance with targets identified in the Level 1 plan result from a prioritization performed by the Metrology and Calibration Working Group (MCWG) using standardized and documented criteria and metrics. In addition, progress assessments of present activities are incorporated and used to justify continued funding. This plan includes a projection of funding requirements, and the associated budget serves as a request from the Metrology and Calibration Principal Center for the funding necessary to implement the projects and achieve OSMA strategic goals.

2.2 Scope

The scope of this annual technical plan includes all NASA Centers and Field Installations for fiscal years 2004 through 2008. Participation by the metrology and calibration organizations at each Center through the MCWG ensures the successful completion of project objectives and the achievement of strategic goals identified by the Office of Safety and Mission Assurance.

2.3 Benefits

The customers of the services of the metrology and calibration organizations at NASA Centers and Field Installations have different needs dependent on their various missions. The MCWG provides a way for specific measurement needs to be addressed in a manner that promotes use at more than one Center. Customers benefit from Agency resources used to improve safety and mission assurance through enhanced measurements and reduced uncertainty. The benefits are delineated in each project description and will be recognized in each success.

3.0 **PRINCIPAL CENTER AND POINT OF CONTACT**

The OSMA delegated the responsibility for Metrology and Calibration Lead Center to the Kennedy Space Center (KSC) and accepted the NASA Metrology and Calibration Program Plan (LO-PL-5) in July 1996. KSC was reaffirmed as the Metrology and Calibration Principal Center in November 1999.

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4.0 **CUSTOMERS**

The metrology and calibration community provides essential services to all NASA programs that must comply with OSMA requirements. These programs continually create a need for technological improvements and reduced measurement uncertainty. Examples of projects supporting the Space Shuttle Program and the International Space Station Program are the development of new standards, such as, the Low Gas Flow Standard; and innovative technology, such as, Microstructure Fabrication.

The customers of the project products include the metrology and calibration organizations at NASA Centers and Field Installations. This metrology and calibration community must improve capabilities and services to continue to be of value to the Agency. To achieve this, the Agency infrastructure must be maintained at a level necessary to support the improvement efforts. Higher productivity at a lower cost is also a key driver. The effort requires continual progress toward improving internal efficiency. Providing cost effectiveness to calibration services justifies the technical program projects as a cost benefit. Examples of projects supporting the metrology infrastructure are those involving Measurement Assurance Programs (MAP's). All NASA Centers and Field Installations are customers of at least one MAP.

4.1 NASA Programs

Agency program management is responsible for funding requirements necessary to achieve a successful mission. Reviewing metrology and calibration needs within a program is performed by the cognizant organizations at each NASA Center and Field Installation. Needs that are specifically program oriented are funded by the program. However, the use of joint funding and cooperative agreements is an integral part of the strategy employed for obtaining project approval.

4.2 Funding Rationale

The costs to be borne by the NASA Metrology and Calibration Program for work done at a participating Field Installation are those associated with activities benefiting the OSMA; not as an intrinsic part of the installation's mission work package. There are two underlying reasons for direct OSMA funding of Agency-wide institutional efforts. They are: (1) the Metrology and Calibration Principal Center identifies and assigns OSMA approved, MCWG recommended, tasks that are important to NASA as a whole, and (2) funds for an installation's basic mission activities should not be diminished by costs associated with Agency-wide benefiting activities.

The work unit elements found proper for OSMA approval are as follows:

4.2.1 Metrology and Calibration Functions:

a. Ground Support Metrology:

- Measurement Standards and Traceability
- Calibration and Measurement Procedures

b. Flight Metrology and Calibration:

- Programmatic Participation
- “Metrology, Calibration, and Measurement Processes Guidelines” reference publication
- Technology Development

4.2.2 Metrology and Calibration Services:

a. Operation of MAP Pivot Laboratories

- Labor for management and leadership, traceability, data analysis and reporting, and round-robin support
- Services for the NIST calibration of reference standards, and repairs and calibrations associated with pivot laboratory impacts
- Equipment, materials, and artifact refurbishment, repair, and replacement

b. Upgrades of present MAPs

c. Development and Implementation of new pivot laboratories

d. Provide specialized calibration services

- Metrology capabilities directory
- Specialized calibration capability

4.2.3 Infrastructure Tasks:

a. MCWG participation

- surveys and workshops

b. Communications

5.0 **APPROACH**

5.1 Determining Needs

Throughout the year, MCWG representatives assess the needs of the metrology and calibration functions at their Center as they apply to the Agency. They define a basic methodology for meeting those needs through the use of realistic goals and proactive strategies. Solutions to problems and the development of tools necessary to meet objectives are documented in the form of a project proposal. At the annual MCWG workshop, progress reports of Center and Field Installation activities, various on-going relevant tasks, and papers describing proposed new work are presented. A review and discussion of the new projects is completed by the total group and an overall, progressive strategy is developed.

5.2 Proposals

Preparation of standardized proposals are completed in accordance with the requirements of the NASA Metrology and Calibration Program Plan (LO-PL-5); published by the Kennedy Space Center. The Metrology and Calibration Principal Center Point-of-Contact reviews proposals and advises the MCWG on areas of emphasis based on the OSMA strategic goals. Using metrics identified herein, the MCWG prioritizes the proposed new projects within the scope of the recognized funding rationale and prioritization criteria. The proposals are summarized in this plan and serve as a request for funding by the Principal Center.

5.3 Management

The individual projects are managed by a project manager at the sponsoring NASA Center or Field Installation. Funding is provided in distributions to the Centers based on the approval of this plan. Schedule progress and the adherence to milestones is the responsibility of the project manager, management at the sponsoring Center, and the Metrology and Calibration Principal Center Point-of-Contact. Compliance to Center level implementation of NPG 7120.5A, "NASA Program and Project Management Processes and Requirements" is required as appropriate. In addition, formal reports and the delivery of products are required to occur at the annual workshop of the MCWG.

Project management is also responsible for making appropriate entries into the Technology Inventory Database. These entries, when required, can be completed at <http://inventory.gsfc.nasa.gov/Inventory2001/input/admin.cfm>

6.0 **PRIORITIZATION**

The annual NASA Metrology and Calibration Workshop is the principal meeting of the MCWG. During the workshop, a session is devoted to a meeting of the program planning committee, which includes the Metrology and Calibration Principal Center Point-of-Contact. A preliminary assessment is performed to verify that the proposed projects are consistent with the Agency's needs as identified in OSMA strategic goals. Subsequently, the entire group reviews the proposals and presentations to evaluate and prioritize the projects. The criteria used in the prioritization process are as follows:

- (1) Benefit - involving as many Centers and Field Installations as possible to provide Agency-wide enhancement of safety and mission assurance.
- (2) Usefulness of Deliverables - ensuring the usefulness of deliverables by developing capabilities to meet new requirements or improve performance.
- (3) Success Likelihood - promoting activities with a quick return of new capability and a high likelihood of success.
- (4) Other Fund Sources - fostering joint activities with other agencies.
- (5) Cost - Striving to achieve the most significant return in products for the funding available.
- (6) Previously Existing Needs - postponing funding activities which can survive on local funding or are extremely expensive and lack reasonable return on investment.

7.0 METRICS

NASA Centers and Field Installations evaluated the projects against the criteria identified in paragraph 6.0. Each criteria category is scored from 1 to 3 points; 3 being excellent. The maximum possible score is 18 for each project. The scores are tabulated and provided to the MCWG. The compilation of the scores for all new 2002 project proposals is indicated below. A prioritization of FY 2003 projects proposals was not required due to funding limitations. Continuing multi-year project funding requirements did not leave any funds for new starts. A summary containing the project description and methodology, expected product, scheduled milestones, and cost is provided in paragraph 9.0 of this report.

	<u>Project</u>	<u>AWCS</u>
1	Internet Based Metrology	323-27
2	Microstructure Fabrication	323-27
3	Portable Hydrazine Instrument	323-27
4	Quantifying Gas Samples	TBD
5	Remote Pressure Transducer Test	TBD
6	Microwave Pulse Power	TBD

	<u>ARC</u>	<u>DFRC</u>	<u>GRC</u>	<u>JPL</u>	<u>JSC</u>	<u>KSC</u>	<u>LaRC</u>	<u>MSFC</u>	<u>SSC</u>	<u>WSTF</u>	<u>Total</u>
1	16	15	11	12	9	11	13	10	14	13	109
2	15	10	10	17	7	10	9	8	12	9	97
3	13	16	10	12	7	12	11	8	14	9	96
4	10	12	9	8	10	9	12	11	12	11	92
5	15	15	9	10	8	10	8	7	14	10	91
6	8	12	6	17	9	11	6	7	9	8	81

8.0 CURRENT PROJECT STATUS AND MILESTONES

8.1 Low Gas Flow Standard (AWCS 323-27-349)

This Kennedy Space Center (KSC) managed project is a continuation of last year which was funded at \$130,000. There is no joint funding for this project, however, there is interest by a significant number of other NASA Centers, Government Agencies, and industry. Funding needed for this project is: FY 2004, \$60,000.

The product of this project is to obtain a primary standard level calibration system for low flow devices with mass flow rates from 1 sccm to 30,000 sccm.

Measurement of gas flow is critical for a number of processes used by NASA Centers. Existing mass flow standards are based on a volumetric method which measures flow rate by timing the displacement of a piston while a gas flows into a sealed cylinder. This method requires accurate knowledge of the gas pressure, temperature, and thermodynamic properties. It is also subject to errors caused by friction between the piston and cylinder walls. The proposed mass flow standard will employ a gravimetric technique, with accuracy depending only on basic units of mass and time. It will be capable of automatically calibrating molbloc systems, eliminating the reliance on the vendor for NIST traceable calibrations. The uncertainty goal is less than 0.1 percent of reading.

This project was behind schedule for FY 2001 milestones due to the contracting effort; however, the contracting effort has been completed and the contractor managed to make up lost time. The project is on schedule and meeting FY 2003 milestones.

The FY 2004 milestones for this project are: (1) Complete software, perform final system calibration, uncertainty analysis and software debug, (2) Complete operation and maintenance manuals, and (3) Deliver the system and provide on-site training.

8.2 Alternating Current (AC) Intrinsic Standard

This Kennedy Space Center (KSC) managed project was a previously proposed new start for FY 2004. This is not a joint funded project, however, previous efforts to develop this standard were funded by the Department of Defense (DOD). The lack of success prompted further analysis and subsequent redirection to a more current project. The funding previously budgeted for this project (FY 2004 - \$20,000, FY 2005 - \$20,000, and FY 2006 - \$20,000) has been shifted to the development of a Portable Pressure Standard (AWCS 323—27-435).

8.3 MCWG Homepage Upgrade (AWCS 323-27-76)

The product of this White Sands Test Facility (WSTF) managed project is an upgraded Metrology and Calibration Working Group (MCWG) Homepage that complies with security requirements. This project is a continuation of last year which was funded at \$9,000. Funding for FY 2004 at \$4,000, and FY 2005 at \$4,000 is required.

The present MCWG web-site has proven to be a valuable tool for interagency information. Since the completion of this project, certain security requirements have been brought to the attention of WSTF personnel involved with maintaining the MCWG Homepage. In order to continue to have access to our information and meet security requirements, a revision to the homepage needs to be implemented. This project was rated number one during the prioritization process of the MCWG.

This project is on schedule and meeting FY 2003 milestones.

The FY 2004 milestones are (1) Gather feedback from MCWG members, (2) implement proposed changes, and (3) prepare report and present to the MCWG. Future milestone will based on changes to system requirements in order to be completed by the close of FY 2005.

8.4 Force MAP (AWCS 323-27-355)

The product of this Stennis Space Center (SSC) managed project is verification of laboratory measurement competence. It provides correlation between National Institute of Standards and Technology (NIST) data and NASA contractor measurement quality at participating Centers using standard artifacts and equipment procured for that purpose. The original estimates were reduced in order to accommodate other projects. This project is a continuation of last year which was funded at \$58,500. Funding for FY 2004 at \$18,500 is required.

A Measurement Assurance Program (MAP) is used to verify measurement competency by comparing the measurement process of different standards laboratories. This is accomplished by sequentially routing a National Institute of Standards and Technology (NIST) certified artifact to participating NASA Centers. A pivot laboratory assumes responsibility for procurement of the artifact, certification of the artifact, shipping, data reduction, and a final report. The results are extremely valuable in determining capability weaknesses and evaluating the sources of unnecessary uncertainty.

This project is on schedule and meeting FY 2003 milestones. The FY 2004 milestones are to evaluate the MAP results and prepare a report of observations and recommendations.

8.5 Flow MAP (AWCS 323-27-354)

The product of this Stennis Space Center (SSC) managed project is verification of laboratory measurement competence. It provides correlation between National Institute of Standards and Technology (NIST) data and NASA contractor measurement quality at participating Centers using standard artifacts and equipment procured for that purpose. The original estimates were reduced in order to accommodate other projects. This project is a continuation of last year which was funded at \$40,500. Funding for FY 2004 at \$22,500 is required.

This project is on schedule and meeting FY 2003 milestones.

The FY 2003 milestones are (1) Assess the MAP results, (2) Obtain final NIST calibration to close the loop, and (3) Begin the second round robin.

The FY 2004 milestones are to evaluate the MAP results and prepare a report of observations and recommendations.

8.6 Portable Pressure Standard (AWCS 3227-435)

This Kennedy Space Center (KSC) managed project is a continuation of last year which was funded at \$40,000. Funding for FY 2004 at \$65,000, FY 2005 at \$65,000, and FY2006 at \$20,000 is required.

Advancements in pressure sensor design and performance has resulted in commercially available sensors that are smaller, more stable and more accurate than the working standards used by in-situ calibration organizations; therefore, requiring standards only available in the calibration laboratory environment. The calibration of transducers continues to be one of the most costly activities associated with measurement systems, involving the removing or sensors from their installed locations, often in areas not easily accessible. However, these same sensor advances coupled with advanced compensating electronics can make the development of a ruggedized portable pressure standard possible. It is highly desirable to have primary standard-like accuracies in a pressure standard for use in remote applications; i.e., the space station.

Milestones for FY 2003 include: (1) Completion of baseline design document, (2) Completion of design architecture, (3) Design reviews, and (4) Acquisition of a prototype. This project was expected to be behind on planned work due to a contract change of the contractor responsible for performance to a task order; however, this project is on schedule and meeting FY 2003 milestones.

The FY 2004 milestones include evaluation of the prototype and will depend on the results.

8.7 Microstructures Fabrication (AWCS 323-27-344)

The product of this Jet Propulsion Laboratory (JPL) managed project will be artifacts that can be subsequently used in agency-wide MAPs. This is new and exciting technology that will have great value and acceptance with metrology and calibration contributions. JPL will provide labor and other procurements. There is interest by a significant number of other NASA Centers, Government Agencies, and industry. This project is a continuation of last year which was funded at \$27,000. Funding for FY 2004 at \$20,000, and FY 2005 at \$20,000 is required.

Under the metrology and calibration program, the project will address and develop the techniques of metrology and calibration from the perspective of MEMS tribology and wear issues for micro or nano-spacecraft applications. The important objective of this project is to calibrate, characterize, and validate various thick and thin film coatings over MEMS microstructures expected to function for long duration in space applications.

Milestones include: (1) Guidelines on the calibration and measurement processes regarding the tribology of MEMS microstructures with and without coatings. (2) MAPs evaluating the robustness of the coating materials. and (3) Developing inspection methods and criteria.

8.8 Portable Hydrazine Instrument (AWCS 323-27-437)

The product of this Kennedy Space Center (KSC) managed project is a prototype instrument for fast detection of hydrazine vapors. This safety related technology is aimed not only for ground operations, but also for Shuttle and International Space Station airlocks. This project is a continuation of last year which was funded at \$34,500. Funding for FY 2004 at \$60,000, and FY 2005 at \$15,500 is required.

9.0 **PLANNED PROJECTS**

There are no new starts planned for FY 2004.

9.1 Internet Based Metrology Standards (previously AWCS 323-27-435)

This KSC project was intended to expand the present NIST Special Test Service for digital multimeters (DMM's) and multifunction calibrators used to test DMM's for the five electrical quantities they normally measure. The project was to be jointly funded by NIST, the Sandia National Laboratories, and NASA funding at: FY 2003 at \$40,000, FY 2004 at \$45,000, and FY 2005 at \$45,000. The funding for this project was shifted to the development of a portable pressure standard last year after a reevaluation of need. The project could not be justified because it would have primarily benefited only one NASA Center.

9.2 Quantifying Gas Samples

The product of this SSC managed project is intended establish methodology for quantifying standard gas samples. Standard gases are used to characterize gas chromatographs. In many cases, the standard gas used is only available commercially. There are discrepancies between different vendors. A suitable method of quantifying gas standards in the laboratory is needed. Funding for FY 2005 at \$30K is required; with an additional \$80K in the out years.

9.3 Remote Pressure Transducer Testing

The product of this KSC managed project is intended to benefit long duration space missions. Presently, transducers must be periodically calibrated in order to ensure that measurement accuracy is maintained. Long duration space flight eliminates the ability of re-calibration. To check the health of a pressure transducer, the sensor would be recessed from the main vessel or line. The recessed portion would be isolated from the main system, and a piston in the enclosed volume would be used to change the pressure above and below the expect readings. Linearity, hysteresis, and repeatability can then be calculated. Several other government agencies are interested in this technology. In addition, joint funding has been proposed by the New Technology Development Division at KSC. Funding for FY 2005 at \$49,000 is required; with an additional \$103,000 in the out years.

9.4 Microwave Pulse Power

The product of this Jet Propulsion Laboratory (JPL) managed project will be the development of new methods for measuring pulse power for video power analyzers and peak power meters. The DC power method uses a known CW power to calibrate a sensor diode, then pulse power substituted and a correction table recorded. The project will establish a modern equivalent where an automated system periodically switches in a precisely known CW power level and reads the measured level on the pulse power meter. The objective is to reduce the measurement uncertainty over a small range to less than 0.1 dB. Funding for FY 2005 at \$28,000, and FY 2006 at \$48,000 is required.

9.5 Laser Thread Measuring System

The product of this KSC managed project is intended to benefit the agency by providing all NASA Centers with the capability to measure threads to a high accuracy. Presently, there are competing systems for thread measurement and often the uncertainty of the process is too high to be able to distinguish bad nuts and bolts. The KSC Standards Laboratories do not have the capability to verify Johnson Gage claims regarding thread measuring accuracy. Funding for FY 2005 at \$38,500, FY 2006 at \$19,000, and FY 2007 at \$30,000 is required.

10.0 RESOURCE REQUIREMENTS

Center	AWCS	Project	FY04	FY05	FY06	FY07	FY08
KSC	323-27-349	Low Gas Flow Standard	60,000				
WSTF	323-27-076	MCWG Homepage Upgrade	4,000	4,000			
SSC	323-27-355	Force MAP	18,500				
SSC	323-27-354	Flow MAP	22,500				
KSC	323-27-435	Portable Pressure Standard	65,000	65,000	20,000		
JPL	323-27-344	Microstructure Fabrication	20,000	20,000			
KSC	323-27-437	Portable Hydrazine Instrument	60,000	15,500			
SSC	TBD	Quantifying Gas Samples		30,000	40,000	40,000	
KSC	TBD	Remote Pressure Transducer Test		49,000	50,000	53,000	
JPL	TBD	Microwave Pulse Power		28,000	48,000		
KSC	TBD	Laser Thread Measuring System		38,500	19,000	30,000	
WSTF	TBD	TBD			43,000	50,000	43,000
KSC	TBD	TBD			30,000	77,000	119,000
JPL	TBD	TBD					48,000
SSC	TBD	TBD					40,000
TOTALS			250,000	250,000	250,000	250,000	250,000
JPL			20,000	48,000	48,000	0	48,000
JSC/WSTF			4,000	4,000	43,000	50,000	43,000
KSC			185,000	168,000	119,000	160,000	119,000
SSC			41,000	30,000	40,000	40,000	40,000
TOTALS			250,000	250,000	250,000	250,000	250,000

Staffing summarized below as (Civil Service/Contractor)

Center	AWCS	Project	FY04	FY05	FY06	FY07	FY08
KSC	323-27-349	Low Gas Flow Standard	0.02/0.3				
WSTF	323-27-076	MCWG Homepage Upgrade	0.00/0.1	0.00/0.1			
SSC	323-27-355	Force MAP	0.00/0.1				
SSC	323-27-354	Flow MAP	0.00/0.1				
KSC	323-27-435	Portable Pressure Standard	0.02/0.3	0.02/0.3	0.02/0.3		
JPL	323-27-344	Microstructure Fabrication	0.00/0.0	0.00/0.0			
KSC	323-27-437	Portable Hydrazine Instrument	0.10/0.5	0.01/0.5			
SSC	TBD	Quantifying Gas Samples		0.00/0.5	0.00/1.0	0.00/1.0	
KSC	TBD	Remote Pressure Transducer Test		0.10/0.5	0.10/1.0	0.00/1.0	
JPL	TBD	Microwave Pulse Power		0.00/0.2	0.00/0.2		
KSC	TBD	Laser Thread Measuring System		0.02/0.0	0.02/0.0	0.02/0.0	
WSTF	TBD	TBD			0.00/0.0	0.00/0.0	0.00/0.0
KSC	TBD	TBD			0.00/0.0	0.00/0.0	0.14/1.3
JPL	TBD	TBD					0.00/0.2
SSC	TBD	TBD					0.00/1.0
TOTALS			0.14/1.4	0.15/2.1	0.14/2.5	0.02/2.0	0.14/2.5
JPL			0.00/0.0	0.00/0.2	0.00/0.2	0.00/0.0	0.00/0.2
JSC/WSTF			0.00/0.1	0.00/0.1	0.00/0.0	0.00/0.0	0.00/0.0
KSC			0.14/1.1	0.15/1.3	0.14/1.3	0.02/1.0	0.14/1.3
SSC			0.00/0.2	0.00/0.5	0.00/1.0	0.00/1.0	0.00/1.0
TOTALS			0.14/1.4	0.15/2.1	0.14/2.5	0.02/2.0	0.14/2.5